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Tension-saturated and unsaturated flows from line sources in subsurface irrigation: Riesenkampf's and Philip's solutions revisited

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Abstract

© 2016. American Geophysical Union. All Rights Reserved.Riesenkampf's (1938), R-38 (referred to here as R-38), analytical solution for steady 2-D flow from a buried line source in a homogeneous Green-Ampt soil, with a wetting plume bounded by a free surface (capillary fringe), is compared with Philip's (1969), (P-69), one for genuinely unsaturated wetting of Gardner's infinite-extension soil. Conformal mappings are used in R-38, from which we derived the flow net, pore-water isobars, isochrones, fields of Darcian velocity and resultant force acting on saturated porous skeleton, fine geometry (shape and size) of the constant-head contour encompassing a mole-emitter or leaky-pipe, as well as the dependence of the total discharge per unit pipe length on uniform pressure in the pipe, capillarity of the soil, radius of the pipe, and saturated hydraulic conductivity. An ovalic "water table" isobar, encompassing P-69 source, is compared with one of R-38 for a fixed discharge and saturated conductivity but adjusted sorptive numbers. The Whisler and Bouwer (1970) relation between the static height of capillary rise and sorptive number is shown to give a good match between R-38 and P-69 isobars. This allows to use R-38 in the source vicinity and P-69 in the far-field zone. Computer algebra (Mathematica) routines are used for visualization of the known and extended R-38 and P-69 solutions.

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Keywords

ADE for Kirchhoff's potential, complex potential, flow net-isobars-isotachs-isochrones, pipe discharge, sorptive number versus air-entrance pressure, Zhukovsky function